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Subject: Re: Title and Summary of Edinburgh Talk
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The Physics and Statistics of Quantitative Remote Sensing: Tractable Characterizations of Terrestrial Surfaces

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Characterizing complex terrestrial surfaces for environmental monitoring and modeling is a principal challenge of remote sensing. The physics of target scattering relates a remote sensing observation to a potentially prohibitive number of parameters describing a scene. For example, the shape, position, and orientation of each leaf in a small cluster of trees could constitute many thousands of parameters for a few tens of square meters of forest. Large parameter sets would be of very little use in environmental monitoring and modeling, which are usually concerned with bulk parameters describing, for example, the height or biomass of a forest stand. Large parameter sets would also be impossible to determine with remote sensing data, which usually constitutes a few observations per resolution cell. If ergodicity is assumed, statistically ensemble-averaging the remote sensing observation corresponds to spatial and/or temporal averaging of measured quantities. Ensemble averaging the physical description of the relevant scattering mechanisms often produces a tractable set of a few bulk parameters, such as stand height or a simple leaf density profile. The physics describing the scattering must be sufficiently simple that, after ensemble averaging, the number of bulk parameters per resolution cell is less than or equal to the number of independent remote-sensing observations. If this condition is not met, ancillary information must be supplied about the scene and the sensing is no longer truly "remote".

This talk schematically describes the remote sensing measurement, and its averaged, physics-based description, in terms of a small number of parameters. The talk will dwell principally on interferometric and polarimetric synthetic aperture radar observations for determining forest structure parameters. These parameters are estimated from the radar data with nonlinear estimation techniques. Quantitative forest profiles result from these estimation techniques applied to radar interferometry and polarimetry. Including hyperspectral optical data in the observation set along with the radar leads to an estimate of leaf area density. Generalizing this analysis of radar and optical data suggests a parameter-estimation paradigm for characterizing terrain from diverse remote sensing data types, also called "data fusion".